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Marker locations for Joint Coordinate System kinematic modeling of a canine stifle unilaterally

Femoral segment markers
Greater trochanter
Craniolateral aspect of the quadriceps m.
Lateral femoral condyle
Medial femoral condyle*

Tibial segment markers
Fibular head
Proximal aspect of tibial crest*
Distal aspect of tibial crest*
Junction of gastrocnemius m. and tendon
Medial malleolus*
Lateral malleolus

* denotes markers that are removed during the acquisition of dynamic trials and reconstructed from a static trial and employed as virtual markers .

Figure 1

Motus 8.5, Vicon Motion Systems, Inc.).Dogs were walked at a velocity of 0.9-1.2 m/s and trotted at 1.7-2.1m/s. Each gait was recorded 4 times. The exact procedure was repeated 5 days following the first, providing 8 trials for analysis. Sagittal flexion/extension, internal/external rotation, and abduction/adduction data were collected (Figure 2). Sagittal flexion/extension waveforms were then compared using two analysis methods. The data was analyzed independently for each method. First, a Fourier transformation was performed for each waveform. Ten Fourier coefficients were produced and compared with a repeated measures ANOVA. Significance was set at $p<0.05$. Then, the same data set was analyzed with GIFA, a multivariate statistical method designed to determine the vector that best separates groups of vectors measured under different conditions. Significance was set at $p<0.05$.

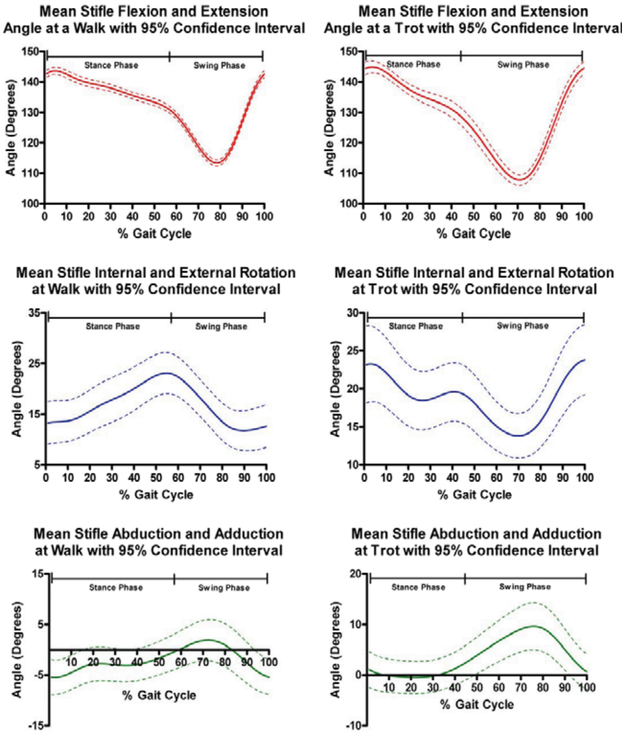

Figure 2

Results: *Fourier Analysis.* Significant inter-dog differences ($p<0.05$) were found between dogs for both the walk and trot. Significant inter-day differences ($p<0.05$) were found for the walk. No inter-day differences were found between dogs at a trot.

GIFA. Significant inter-dog differences ($p<0.05$) were found between dogs at a trot (Figure 3). No inter-dog differences were found between dogs at a walk. Significant inter-day differences ($p<0.05$) were found for both the walk and trot.

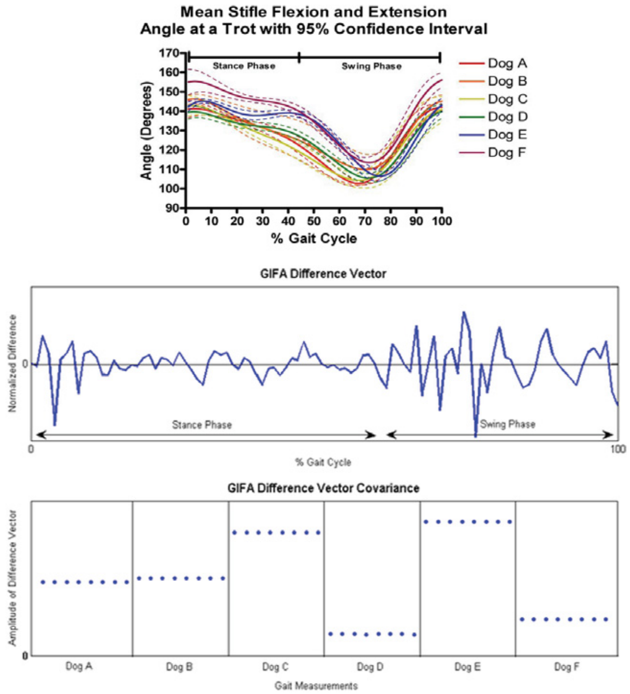

Figure 3. Mean stifle flexion and extension angle at a trot for all dogs with 95% confidence intervals. Significant differences between dogs, as illustrated by this comparison, were found at a trot. The temporal differences between dogs are indicated by the GIFA Difference Vector plot. GIFA produces a multi-dimensional vector representing the most significant differences beteen the dogs being compared. For illustrative purposes this vector is depicted on the graph as a waveform corresponding to the temporal differences between gaits. Changes in amplitude away from baseline [0] correspond to the degree of difference detected between dogs. However, the establishing vector is unitless and therefore the direction of waveform movement along the vertical axis, away from baseline [0], is arbitrary. The GIFA Difference Vector Covariance plot depicts a statistically significant change between dogs. Each (•) represents an individual trial. Small movements along the vertical axes within a method indicate slight variation between individual trials within that dog. Differences in vertical axes position between the grouping of gaits (Dog A, Dog B, Dog C, Dog D, Dog E, Dog F) indicate significant differences between groups. The distance between the grouping of gaits along the vertical axes denotes the degree of difference between them. The actual position of the groups along the vertical axis represents a relative quantity.

Conclusions: Both hypotheses in this study were accepted. The use of the JCS marking system allowed for the collection of 3-D stifle motion. It produced sagittal flexion/extension waveforms that were consistent with previous kinematic studies of the canine stifle, and provided information regarding the additional axes of joint motion. Furthermore, GIFA and Fourier both provided the ability to assess differences in gait waveforms. Variation in the results between both methods may be attributed to the fundamental differences in the two analysis methodologies. Given that GIFA gives rise to eigenvectors that are functions of time, it may prove beneficial in temporally isolating gait differences.

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STIFFENED PATTERN OF MOVEMENT IS ASSOCIATED WITH WORSE PHYSICAL FUNCTION IN PEOPLE WITH KNEE OSTEOARTHRITIS

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Purpose: People with knee osteoarthritis (KOA) walk with decreased lower extremity joint excursions and increased muscle co-contraction (CC). Although this stiffened pattern of movement may affect joint loading and disease progression, there is limited information on how this pattern relates to physical function. We examined the association between lower extremity joint excursion and muscle pairs CC with physical function in people with KOA during gait and step down.

Methods: Subjects with KOA over the age of 40 participated (n=65). Severity of symptoms determined the Most and Least-Affected (MA and LA) leg. Physical function was measured by a performance based (Get up and Go test) and a self-reported method (WOMAC). Principal component analysis combined these two measures into one component measure of physical function (CPF)-higher scores indicate worse function. Motion analysis and electromyography were performed during gait and step down for both legs. Hip, knee and ankle joint excursions of MA and LA legs were calculated during the loading phase of gait and of step down. Mean CC of the following 5 muscle pairs were computed during the loading phase: Lateral Quadriceps (LQ) and Lateral Hamstrings (LH), LQ:LH; LQ and Lateral Gastrocnemius (LG), LQ:LG; Medial Quadriceps (MQ) and Medial Hamstrings (MH), MQ:MH; MQ and Medial Gastrocnemius (MG), MQ:MG; and Tibialis Anterior (TA) and LG, TA:LG. Four stepwise multiple linear regression analyses were performed using CPF as dependent variable. One regression was performed for each condition (gait and step-down) and each leg (MA and LA). Independent variables were joint excursions and mean CC of muscle pairs respective to each condition and leg. Gender, age, height and mass were controlled for their potential confounding effects. Independent variables were entered in a stepwise manner. Probability of F change was set at 0.1 to enter and 0.15 for removal.

Results: In all four regression analyses, after controlling for demographic variables, decreased joint excursion and increased CC explained additional variability in CPF. During the gait conditions, LQ:LH explained additional variability in CPF on both legs, whereas ankle excursion explained additional variability only on the LA leg. During LA step down, TA:LG, LQ:LH, and ankle excursion explained additional variability in CPF. On the MA leg step down, MQ:MH and hip excursion explained additional variability in CPF (Table 1).

Table 1. Stepwise Regression Models predicting CPF

	Variables	Total R^2	ΔR^2	Sig. F Δ
Regression 1	Demographics	0.32	0.32	0.00
Gait-Least Affected	LQ:LH mean CC	0.36	0.03	0.09
	Ankle Excursion	0.39	0.03	0.01
Regression 2	Demographics	0.24	0.24	0.00
Gait-Most Affected	LQ:LH mean CC	0.30	0.07	0.02
Regression 3	Demographics	0.24	0.24	0.00
Step Down-Least Affected	TA:LG mean CC	0.32	0.09	0.01
	Ankle Excursion	0.36	0.04	0.06
	LQ:LH mean CC	0.41	0.04	0.04
Regression 4	Demographics	0.23	0.23	0.00
Step Down-Most Affected	MQ:MH mean CC	0.29	0.06	0.03
	Hip Excursion	0.33	0.04	0.07

Demographics: Gender, age, height and mass

Conclusions: Our results showed that after controlling for demographic variables, decreased joint excursion and increased CC were associated to worse CPF. Further investigation is needed to determine if exercise therapy may affect this stiffened pattern, and if changes in this pattern are associated with changes in physical function.

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INTERACTION BETWEEN MASS AND ALIGNMENT ON KNEE ADDUCTION MOMENT IN PATIENTS WITH KNEE OSTEOARTHRITIS

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Purpose: The purpose of the present study was to evaluate the interaction between mass and alignment when predicting the KAM in patients with knee OA. We hypothesized that the effect of body mass on the KAM would be moderated by the extent of limb malalignment.

Methods: 354 patients with knee OA were recruited from a cohort of patients being screened for participation in a prospective study of osteotomy procedures. Patients underwent 3-D gait analysis using an 8- camera motion capture system and modified Helen Hayes markers set (Eagle EvaRT; MAC, Santa Rosa, CA) synchronized with a single floor-mounted force plate (AMTI, Watertown, MA). The peak KAM (Nm) was calculated from the kinematic (60Hz) and kinetic (1200Hz) data using commercial software (Orthotrak 6.2.4; MAC, Santa Rosa, CA) and custom post-processing techniques. Gait speed, toe out and lateral trunk lean were also determined. Body mass (kg) and height (m) were measured prior to gait testing. Frontal plane alignment was quantified using the mechanical axis (hip-knee-ankle) angle (deg) measured from standing long-cassette radiographs. We tested for effect modification by entering the interaction term (mass*mechanical axis angle) into a linear regression model predicting peak knee adduction moment. We then split the sample into three subgroups based on tertiles for mechanical axis angle and evaluated the relationship between mass and knee adduction moment for each subgroup using simple linear regression.

Results: The interaction term (mass*mechanical axis angle) significantly (p=0.04) contributed to a model predicting the KAM while controlling for height, gait speed, toe out, trunk lean, mass and mechanical axis angle (Total R2=0.67). In patients with severe varus alignment ($\geq$9deg) the KAM increased 0.47 Nm for every 1kg increase in mass. In patients with moderate varus alignment (4.80 to 8.99deg) the KAM increased 0.38 Nm for every 1kg increase in mass. In patients with mild varus alignment ($\leq$4.79deg) the KAM increased 0.23 Nm for every 1kg increase in mass (Figure 1).

Conclusions: These findings illustrate that there is a significant interaction between mass and alignment when using these two

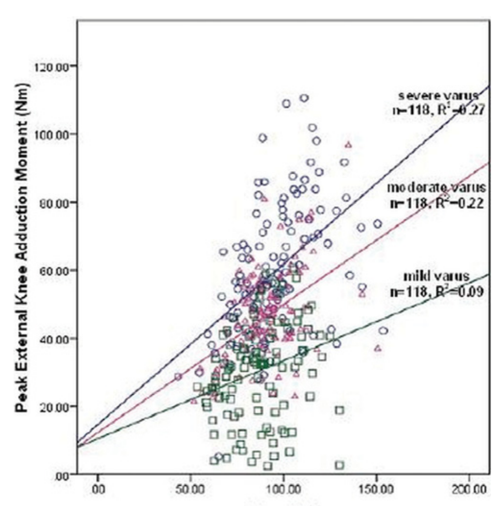

Figure 1. Scatterplot illustrating the relationship between mass and knee adduction moment for patients with different extent of malalignment.